

*Poster Session*

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Wednesday, June 11

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**Blue Room**  
**2:30 - 5:30 p.m.**

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Poster Session

J. F. DeFrance, J. Degioanni, C. Hymel, F.C. Schweitzer, S. Estes, R. Calkins, F. Kutyna, and I. Tarkka. **Development of correlative measures for the assessment of attention and memory.**

This project<sup>1</sup> developed a collection of performance paradigms to detect subtle changes in attentional and memory processing, and established baseline profiles with more than 50 normal volunteer subjects. The tasks were specifically designed to be provocative of frontal and temporal lobe pathways, and the initial emphasis was upon establishing task *sensitivity*, *validity*, and *reliability*. The central concept is that prolonged stress can induce physiologic changes along the prefrontal-temporal lobe axis - which can be manifested as changes in a person's mood, ability to sustain attention, ability to suppress unwanted behaviors, alertness to the environment, and ability to handle interfering information. Since isolation, confinement, and circadian rhythm changes are stressors, the implication is that astronauts are likely to exhibit psychological changes will appear as cognitive difficulties, such as attentional and memory lapses. The tasks and procedures were designed to have ecological validity for monitoring human performance in a variety of remote and isolated conditions - including *space* by combining behavioral (e.g., performance) measures with simultaneously acquired EEG/ERP components. The performance battery provides important information related to response accuracy and reaction time. The EEG analyses focuses on the spectral content, while the ERP studies focused upon both *automatic* (e.g., N150, P200) and *controlled* (e.g., P300, N400) components.

There is a confluence of research suggesting that stress due to isolation, or lack of normal circadian timing cues, can lead to a decline in the ability to perform complex tasks - most often within the domains of attention/concentration and memory. Thus, the end product was essentially a specific set of protocols, with enhanced diagnostic capability, ideal for continuously monitoring for the onset of difficulties with attention/concentration and memory. This will be extremely useful in isolated environments as expected in habitats such as a space station or a lunar base, and would be capable of being developed into an ambulatory, non-invasive diagnostic aid to understand psychological mechanisms for coping with environmental stressors.

Attention and memory functions are the result of a complex interaction of discrete brain systems, so their study is optimally addressed through a multifaceted approach. The final performance battery consisted of seven basic performance tasks, plus alternate forms suitable for repeated testing. They were designed to determine an individual's capacity for sustaining attention (i.e., vigilance), consistency of performance, effectiveness of meaningful stimuli, freedom from distractibility, willingness to exert effort, sensitivity to interference, and learning curves. Both *implicit* and *explicit* memory functions are sampled. Finally, a model of attentional processing was also developed, as well as exploration of ERP dipoles with BESA.

A continued search for the physiological boundaries of the various forms of attention and memory disorders is needed because of symptom overlap with certain affective disorders, such as anxiety and depression. Also, the capacity for accurate performance monitoring is vital for ensuring NASA personnel safety and successful missions, and has great health care implications for the general population.

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<sup>1</sup> Supported by NASA #NAG9-413

## **Biodynamical Responses of the Crewmember Head / Neck System During Emergence Ejection**

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### **Abstract**

An efficient method for gross motion simulation of a crewmember in aeronautical force environment is presented. The method is a modification of SUPERCRAASH victim simulation code. It is designed for study and analysis of the dynamical responses of a crewmember on ejection propeller shock and windblast during emergence ejections. Using the method, together with experimental data, we obtained the relative trajectories, relative velocities and relative accelerations of crewmember head mass center, angular velocities and angular accelerations of crewmember head and neck, and joint reaction forces acting on each body at the moment out canopy in different Mach Number and different constraint configurations. These response parameters are then applied to analyzing Head Injury Criterion(HIC) values and comparing with nontraditional measures of head injury as affected by combinations of rotational and translational motion. Some conclusions and recommendations about this approach to studying crewmember dynamics in aeronautical force environment are presented.

## FECUNDATION IN THE SKY : A TEN YEARS OLD EXPERIMENT IN MICROGRAVITY .

Luc Henriët , Université de Louvain , Belgium .

### INTRODUCTION.

To throw male and female gametes in the space could seem to be a strange idea as well as to make mustard in weightlessness , few reasons suggesting that the results should differ from terrestrial accomplishments . The fecundation indeed , occurred on the earth and endures since millenaries . Precisely , because such a performance , fecundation experiments in microgravity will seem less strange when one is thinking that the whole world life is entirely sustained by the fecundation ; the fate of all the living beings of all the species , the human species included , is closely linked with their reproduction capacity . Likewise , this ability holds in his power the solution for the heavy world hunger problem .

Moreover , for the scientists , the penetration of one cell in an other cell appears as an exceptional fact ; this fact results of a long serie of chemical and physical reactions , some of these are clearly explained , some are not well definite , many remains unknown .

The monospermy , excluding all the spermatozoa except one , illustrates a recently open field of researches for the medical and zoological sciences : the factors of attachment and of non-attachment .

On another hand , considering the efficiency of the fecundation , it must be said that , in the mammals , the success rate is not admirable : the survival rate reaches a little 50 % . All increasing method should be welcome .

Considering gravity and microgravity , it may be said that spermatozoa and oocytes are little , microscopic beings , but they have a weight and they undergo unceasingly , throughout the genital tracts , the law of gravitation ; this fact increases in importance since the probability of an extraterrestrial life increases the preoccupations of the astronomers . If the probability becomes a certitude , the gravity should be considered as a variable parameter for the fecundation .

Finally , opposite to microgravity experiments , centrifugations of sperms samples revealed that an increased gravity is injurious for the spermatozoa , the tails agglutinate in an inextricable network imprisoning all the cells .

Experiments of fecundation in microgravity don't appear so as a vain and luxurious amusement but as offering a large field for interesting investigations .

### MATERIAL & METHODS .

#### 1. The Species and the Gametes .

Gametes issued out bulls and cows of the breed "Blanc Bleue Belge" were selected because this material is easy obtainable and also because of the precise fertility controls performed in the artificial insemination centers . Highest fertile sperm samples were stored in liquid nitrogen until the ultimate moment before the flight . Oocytes were carefully picked out ovaries and cultured in an " artificial heart-lung-kidney system (5) ; the morning after , they were transferred with culture medium in a test tube maintained at 38,5° C. in a thermos .

The reunion of the gametes happened , the same morning , at the aerodrome , the semen being added to the test tube after thawing , all together was confided to the aviator and embarked in a Fouga Magister

#### 2. The Flights.

The aviator described 15 parabolas during 25 -30 seconds each . After landing , the test tube was immediately cooled and transferred to the laboratory for a first examination under a Normanski phase contrast microscope , and later the gametes were fixed for an examination under electron microscope .

### THE RESULTS .

The first experimental flight happened at 4 March 1987 . 23 oocytes were recovered after landing , numerous spermatozoa were found surviving without agglutination , 4 oocytes showed signs of degeneration , 3 oocytes showed the first stages of fecundation (cytoplasmic retraction , expelling of polar body .)

These numbers are considered as normal .

The flights were repeated three times with comparable results , no special disturbance was detected to.

### CONCLUSION .

The in vitro fecundation don't seem suffering of short and repeated microgravity periods . That is to be compared with the effects of the increased g during the centrifugation . That can be also compared with the results on the Earth and can be used as a comparative experimental field .

From a practical point of view , the price of a minuscule flap-seat in a space vessel hinders many original experiences ;this parabolic flight demonstrates that some could be performed at lower cost ; fortunately the gametes seems to be an ideal material :easy obtainable , cheap , extremely little , .(about 20.000 can be lodged into the volume of a ring bezel) ,that all together involves a lighten embarkment material . Moreover , the spermatozoa shows instantaneously that the life conditions are favorable or not and that ,without any hard or long manipulations .

All the here above mentioned problems were of course not solved or elucidated , these immense task asks more and more parabolas . But unwanted researches join the same field as for instance , the experiments carried out by the laboratories Helena Rubinstein (beauty products) , in microgravity with as purpose the study of the factors of attachment and non-attachment at the level of the membranes (4.)

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3. **Henriet L** ,Athena , La fécondation dans l' espace ,n° 32 June 1987 , p.45-50.
4. **Trends Tendances** , 6 Octob. 1988 .

5. **Henriet L, Hulhoven D , Seynaeve V , Maion J-H** ,10 th Internat. congress on animal reproduction and artificial insemination , Urbana Chmpaign ,14-6-84 ,p.227-229 .

FIGURES : Oocytes fertilized in the space(phase contrast ) and penetration figure (electron microscopy)

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Belgium .



## A MODIFIED BOTEX INCUBATOR AS A TRANSPORT SYSTEM FOR DEVELOPING CRICKETS INTO SPACE

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### INTRODUCTION

Specific scientific problems demand suitable animal models for their solution. In gravitational physiology research, however, also suitable transport systems are necessary, which enables the scientist to expose his samples to micro- or hypergravity for many days or weeks. With crickets as the animal model and the modified incubator BOTEX as the necessary transport system, a suitable combination is available which allows to investigate questions on development and regeneration of gravity sensitive sensory systems and the underlying neuronal network. - Why crickets are useful animals? Their gravity sense organs and related responses are well defined; they possess two roll sensitive interneurons which can be identified by neurophysiological recordings; the gravity sensory system is able to regenerate under earth- and hypergravity conditions. - What is the advantage of the BOTEX incubator so that modifications were useful? BOTEX (Botany Experiments), originally developed for investigations in the field of botany, offers a large space to transport many subjects; it is also equipped with a 1g-reference centrifuge. Here, we describe some modifications of this incubator and present test experiments with crickets to demonstrate the usefulness of this system.

### METHODS

BOTEX modifications included the development of survival conditions in closed mini-containers (CRIC1 to CRIC4) and a proper temperature range control. The system was tested several times in experiment verification tests (EVT) performed in the course of the preparation of the experiment CRISP (Crickets in Space) which will be flown on NEUROLAB. Eggs, 1st, 4th and 6th instar larvae were brought into the closed BOTEX incubator for 20 days at a temperature of  $27 \pm 1$  °C. The usefulness of the system was demonstrated (i) by animals' survival rates, and (ii) their moult numbers during the 20-days period.

### RESULTS

It was found that cricket larvae up to the 5th instar which were supplied only with autoclavated rat food pellets, 2 ml water and a piece of filter paper can be reared in tightly closed Petriperm dishes with an internal volume of 25 ml for at least 20 days. At least 50% of the larvae survive in these mini-containers. The highest survival rates were seen if the number of individuals were between 6 and 10 per Petriperm dish. The optimal number depended on the age at the beginning of the development in the closed system. Hatching from eggs occurred at a similar percentage. Larvae performed a mean number of 3 moults. Gravity related responses, recorded after these rearing procedure, were similar to that observed in the instars which developed under standard laboratory conditions. The survival rate and number of moults recorded from crickets after the 20 days lasting 3g-condition was at the same level as that in the 1g-reared controls. The modified BOTEX incubator allows the transport of 80 Petriperm dishes used for the µg- or hg-samples. Under space conditions, 30 dishes for the inflight 1g-control, 20 for a 0.7g- and 10 for a 0.3g-condition are also available. There is additional space for 8 larger containers of 415 to 625 ml volume for the transport of stage 6 and older instars under µg-conditions. Tests with these containers demonstrated similar survival and moulting rates.

### CONCLUSION

The transport of insects, used as experimental models to study basic phenomena of developmental biology, under hypergravity conditions can be performed in an extremely reduced ecological environment for at least 20 days. The developed procedure will be used to transport eggs and larvae of crickets into space on NEUROLAB in 1998. The aim of the project CRISP is to study the effect of gravity deprivation (i) on the morphological and functional development of neurons with well-developed gravity sensitivity and (ii) on the morphological and functional regeneration of a gravity sensory system. The principles of the CRIC containers and the feeding strategies can be applied even to other animals as well as to other space-tested transport systems.

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## CHROMOSOMAL ABERRATIONS IN PERIPHERAL LYMPHOCYTES OF COSMONAUTS AND ASTRONAUTS AFTER SPACE FLIGHTS

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### INTRODUCTION

The analysis of chromosomal aberrations in peripheral lymphocytes of exposed persons is the only feasible method so far to assess mutagenic activities of environmental agents *in vivo* in man. Many of the radiation types occurring in space can only approximately be simulated on earth ( e.g. heavy ions, protons, HZE particles). Therefore the relative biological effectiveness (RBE) for many radiation types in space are not well determined and some of them could have been underestimated.

### METHODS

The normally used method to determine radiation exposure and to assess the received dose is scoring of chromosomal aberrations in phytohemagglutinin stimulated peripheral lymphocytes from venous blood. Chromosomal aberrations can be classified as so called "unstable chromosome aberrations", namely dicentric and ring chromosomes and the "stable chromosome aberrations" such as insertions and translocations. The latter type of chromosome aberrations normally allows the affected cells to proliferate and eventually to form cell clones. Stable aberrations can be analyzed by the method of fluorescence *in situ* hybridization (FISH) of selected chromosomes. We performed our investigations with the peripheral lymphocytes of astronauts and cosmonauts before launch and directly after return.

### RESULTS

Significant elevations of the frequencies of chromosomal aberrations (dicentric and ring chromosomes) were found in the peripheral lymphocytes of astronauts from MIR missions '94-'95. Using FISH stable aberrations were found, but the data do not allow statistical analyses up to now.

### CONCLUSION

Radiation in space leads to chromosomal aberrations in the peripheral lymphocytes of astronauts and cosmonauts. Our data indicate a mutagenic risk of space flights.

## METHOD FOR ESTABLISHING LONG TERM BONE MARROW CULTURES UNDER MICROGRAVITY CONDITIONS

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### INTRODUCTION

Exposure to microgravity leads to physiological abnormalities. The exact cause of these conditions has yet to be determined. In order to simulate spaceflight conditions here on earth, we have established long term bone marrow cultures under microgravity. These cultures are compared with a control containing bone marrow grown under normal tissue culture conditions.

### METHODS

Using a hemocytometer, cells from 1 ml of normal human bone marrow are quantified. Trypan blue is used to check for cell viability by dye exclusion. Bone marrow is now resuspended into 9 mls of media (IMDM with 10% fetal calf serum and 10% fetal horse serum) and placed into the 10 ml HARV vessel of the *Synthecon* bioreactor. The speed of the bioreactor is maintained at a rate in which cells are visibly suspended. They are maintained in a 5% CO<sub>2</sub> tissue culture incubator at 37°C and 99% humidity. A control is set up in a 75 cm<sup>3</sup> flask, containing 1ml of normal bone marrow and 9 mls of media. After six days culture is measured. Small aliquots are removed to test for changes within culture. Culture should be established in one to two weeks within control flask.

### RESULTS

Initially,  $2.08 \times 10^6$ /ml cells are placed under microgravity conditions as well as into control flask. After six days, the microgravity induced tissue culture yielded  $3.0 \times 10^5$ /ml cells, this being an 86% decrease. The control flask contained  $2.9 \times 10^6$ /ml cells, a 39% increase.

### CONCLUSION

Spaceflight conditions appear to decrease cell growth potential, and infer that the necessary biological processes for normal cell proliferation are gravity dependent. Further testing in which time period for testing is increased should substantiate these results.

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#### Acknowledgments:

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#### References:

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## REPRODUCTION UNDER SIMULATED WEIGHTLESSNESS ---MAMMALIAN *in vivo* EXPERIMENTS UNDER SUSPENSION---

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### INTRODUCTION

A tail-suspension model to simulate weightlessness has been widely used for studies of physiological changes not only of the musculoskeletal system, but also of the cardiovascular system. In this study, we applied this model in order to investigate whether it is possible or not for male spermatogenesis to occur, and for female rats to maintain pregnancy on this model.

### METHODS (Table)

#### Experiment 1

Adult Sprague-Dawley rats (2 male, 30 female) were utilized in the study. Male rats were suspended with the right inguinal canal ligated loosely for 14 days, and female rats were suspended after copulation (the day when spermatozoa were identified on a smear from a female rat referred to as Day 0 for her in this paper). Duration of suspension of female rats was chosen dependent upon events to be confirmed in the course of pregnancy. To demonstrate the effect of suspension on implantation, the first and second groups consisted of non-suspended rats penetrated at the base of the tail in the same way as suspended rats, and the rats suspended during the former half of pregnancy. The third and the final groups consisted of rats suspended during the latter half and throughout the pregnancy, respectively.

#### Experiment 2

To confirm our hypothesis, female rats were suspended throughout the pregnancy again but for this time they had been suspended for a week beforehand. A week after presuspension ended, the rats were copulated and suspended again. Morphological analysis of young was performed in search of teratism.

#### Experiment 3

Eggs were collected by flushing the oviducts and the uteri of female rats after they were mated and suspended as described in Experiment 1 until around Day 4. Then the eggs were observed under a stereo microscope and the stages of embryo development were determined.

### RESULTS (Table)

Histological analysis of male rat testes showed that the testes on the ligated side were scarcely impaired, while the others were degenerated presenting similar appearances of cryptorchidism. Levels of serum testosterone were lower than control values. Although these findings were seen in literature, in the present study we treated the one side of testes and left the other of the same animal unligated, of which the results mean the testis was degenerated mainly by local high temperature rather than by humoral factors. As for female rats, implantation occurred in Experiment 1, and from Experiment 3 we knew that the preimplantation embryos developed to the morula/blastocyst stage without delay even if the mother was suspended. In Experiment 1 the third group rats failed to deliver, but if the rat was suspended throughout the pregnancy, it succeeded in parturition. To corroborate this result that the longer the suspension period, the easier the delivery would be, we carried out Experiment 2, which resulted in accordance with our hypothesis. Macroscopically, newborn young seemed normal. Details of morphological analysis will be presented at the conference.

## CONCLUSION

Several models to suspend animals were known and they were said to bring about stress to the animal to some extent. However, in this study it was indicated that a tail-suspended rat, if it was acclimatized to its environment, could succeed in parturition. By employing this model, we can certainly elucidate some new aspects of mammalian reproduction in space.

Table. Experiments and Results (female rats)

Experiment (n)	presuspension	suspension	results
Experiment 1 (20)	-	-	control
	-	Days 0-12~	implantation occurred
	-	Days 10-20~	parturition unsuccessful
	-	Days 0~22	parturition successful
Experiment 2 (5)	7 days	Days 0~22	parturition successful (easily)
Experiment 3 (10)	-	Days 0~4 $\frac{1}{2}$	Early development of embryos was normal.

# TOWARDS HUMAN MOVEMENT ANALYSIS WITHOUT THE USE OF MARKERS

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## INTRODUCTION

Among the different applications of human motion analysis, the study of humans in weightlessness conditions leads for example to the understanding of the role of the gravity in the control and the coordination of movements by the nervous system.

A few years ago, the quantitative analysis of human motion was done by chronographic techniques. Nowadays, the systems of motion analysis give a description of the kinetic and the dynamic parameters of tri-dimensional human motions in time. Unfortunately, available systems are based on the tracking of markers located on the human body. This is the case of the 'Kinelite' system based on the real time recognition of reflective passive markers : a set of few cinecameras acquires digital sequences of binary images ; the tracking of these sequences allows a tri-dimensional reconstruction of the motion of the markers. Consequently, the human motion analysis is limited to the study of the kinetic and the dynamic parameters of the markers.

The aim of this work is the analysis of human motion in the tri-dimensional space without using markers. The method we propose uses gray level image processing techniques. It maps a tri-dimensional model on the images of the body in motion acquired by three cinecameras ; this volumetric model, which can be seen as a mathematical description of the movement of the human body during the time, allows the extraction of the right parameters of human motion. In order to facilitate the understanding of this method, we first describe it in the bi-dimensional case at the beginning of the following paragraph ; the tri-dimensional extension is then briefly approached.

## METHODS

We have a sequence of digital images which represents a human body (or a part of it) in motion.

First of all, we apply an optical flow technique for determining an estimation of the displacement of each picture element (pixel) between each pair of successive images. We obtain a sequence of displacement vectors field by this process with differential methods based on the spatio-temporal changes of the gray levels. The largest displacements are obtained along the boundaries in motion.

Then, a segmentation stage is processed on the displacement fields. This segmentation consists in the extraction of pixels having a large estimate displacement compared to their neighbors. By seeing each point of a displacement vectors field as a geographic point with an altitude proportional to its displacement magnitude, the sets of extracted points are the crest lines of this virtual tri-dimensional map. So, we obtain a sequence of sets of points which represents roughly the boundaries of the objects in motion in our scene at any moment.

The next stage is the matching between each cloud of points with a model. With this end in view, we use a volumetric model and each member of the human body is described by an object. In the case of the study of a leg, three objects are necessary to describe the thigh, the calf and the foot. We notice that this decomposition can be made finer in accordance with the study. We chose the superquadric curves, the equation of which is recalled below, as the model of a member.

$$F(x, y) = \left( \left( \left( \frac{x}{a_1} \right)^{2/\epsilon} + \left( \frac{y}{a_2} \right)^{2/\epsilon} \right)^\epsilon \right) = 1.$$

By making vary the coefficient  $\epsilon$ , we obtain a rectangle when  $\epsilon$  is close to 0 and a diamond-shape when  $\epsilon$  is equal to 2. We can remark that  $\epsilon=1$  gives an ellipse with  $a_1$  and  $a_2$  the values of the radii.

Finally, we solve the matching between each cloud of points and the superquadric-based model by using a fuzzy clustering technique. It consists in the minimization of the following equation :

$$\sum_{c=1}^{nb\_clusters} \sum_{p=1}^{nb\_points} \mu_{cp}^m \cdot D_{cp}^2,$$

with  $\mu_{cp} \in [0, 1]$  being the fuzzy membership of the point  $p$  to the superquadric  $c$  and with  $D_{cp}$  being the distance between this point and the superquadric curve. The solution of this non-linear system gives the parameters of the superquadrics which fit at best with the set of points. This system of equations is iteratively solved and is initialized at each step with the results obtained at the previous step. This method does not require any operator's action since the computer knows the model and its rough initial position.

The tri-dimensional procedure consists in matching at any moment the three bi-dimensional contours computed from three different calibrated cinecameras with different points of view in order to build a tri-dimensional volumetric model based on tri-dimensional superquadric objects. Let us notice that this reconstruction procedure requires some tests of coherence : first, a spatial coherence test in order to respect the geometry of the human parts, each part being taken independently and then considered with its interactions with the other parts ; secondly, a temporal coherence test in order to ensure the dynamic laws of the human body. Finally, this tri-dimensional model takes into account each of the bi-dimensional contours issued from the calibrated cinecameras, while respecting the geometric and the dynamic spatio-temporal laws of the human body motion. Such a tri-dimensional model may be animated and allows the relevant searched parameters to be calculated.

## RESULTS

We complete now the tri-dimensional reconstruction. The images presented below represent the movement of the bi-dimensional models obtained with and without markers, applied to the motion of a mannequin's left leg. The left stick figures are built by linking the markers located at the joints. In the case of our approach at the right side, we obtain a decomposition of the leg in three volumetric objects. So, this model allows a more precise extraction of dynamic parameters compared to the markers-based technique.



time 0

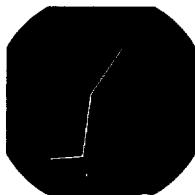


time t

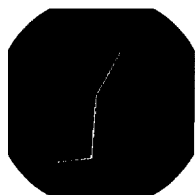
initial sequence



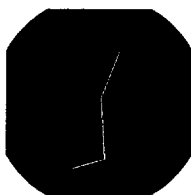
time N



time 0

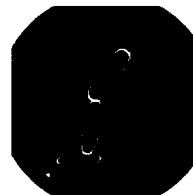


time t

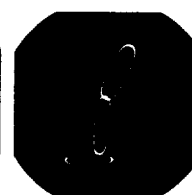


time N

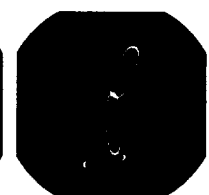
markers-based model



time 0



time t



time N

superquadrics-based model

## CONCLUSION

We have presented in this paper a new approach for analyzing human motion in space without the use of markers. Unlike the present systems of motion analysis with markers which require a preliminary step in order to stick markers accurately, the proposed approach first does not require this delicate stage, secondly ensures a repeatability between operators and thirdly, is less sensitive to the changes of the illumination of the scene.

The presentation of this new approach is followed by some bi-dimensional results. They are encouraging but perfectible : however, in a near future, a further development of the reconstruction procedure will allow a presentation of tri-dimensional results with the respect of the geometric and the dynamic laws of the human body in motion (previously called tests of coherence) which are done during this reconstruction procedure.

The first results of the comparison between the parameters obtained with the markers-based method and those obtained with this method allow us to be optimistic as for the future of this study of feasibility as a new generation of kinesigraph.

## HABITABILITY REQUIREMENTS FOR A COGENT MARS MISSION

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### ABSTRACT

New goals set for the U.S. Space Program focus on re-establishing the human presence on the Moon and sending the first manned mission to Mars in the 21st century. The necessary first step in supporting these goals is identifying habitability requirements that drive the development of new technologies.

This paper reviews long duration Space stay experiences of the American astronauts of the Shuttle-Mir missions and even some Russian cosmonauts who have been in Space for extended periods of time. It critically analyses the habitability requirements planned for International Space Station Alpha.

It takes a look at the Martian landing sites, climate, surface chemistry, radiation, temperature, water and volcanism. It then goes on to analyse and synthesise key habitability requirements for a Mars mission given the current planning, transit times, communication constraints, crew compliment etc. Key habitability issues include environmental factors, architectural/design issues, medical/health concerns, psychological issues, life-support mechanisms, sociological and cross-cultural issues.

It also proposes "testable" habitability principles for the BIOPLEX (a 90-day confinement experiment to be conducted by NASA later this year) and the International Space Station Alpha.

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## THE SAUCER CONCEPT FOR SPACE HABITATS

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### ABSTRACT

After more than 30 years of manned Space flights, when the idea of colonising beyond the earth seems only an extension of the present, it is time we went beyond the pure purpose of technology to *humanise the design of our Space habitats*. Both existing (Mir) and planned (Alpha) enclosures are tubelike, cramped and present a hostile environment for long duration stays.

This paper proposes a *change in paradigm*--from the *capsule to the saucer*. These two shapes are compared and analysed for environment perception, comfort and movement, work and living space, human ecology and safety. Piecemeal construction of the saucer has been detailed out. Floor plans for the habitation deck have been proposed and two sample designs for interiors included. It is envisaged that the astronaut be a key member of the design process. The ways in which spaciousness will enhance the quality of life aboard our Space habitats, have been discussed.

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## NEW WAY IN MODELING THE GROWTH OF THE ORGANISM

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## INTRODUCTION

Modeling the body mass growth, in relation to the nourishment, motor activity and the influence of various stressing factors, represents a very important question so far the body mass development of a man and animals are concerned. The classical growth functions of Gompertz, Robertson, Bertalanfy, Richards, and also the methods of the linear or non-linear regression analysis, often used to the construction of the growth curves, describe the body mass growth of the organism formally, as a pure mathematical function of time. The common denominator of all above mentioned growth functions is that the coefficients formulating the course of the growth curves, have none direct relations to the mechanisms taking part in the transformation of the feed ingested, to the mass of the product formed. These coefficients must be calculated only from the experimental growth values and therefore their validity is limited.

New methodical approach named selfregulating growth model (SGM), (Novák 1996), generates the growth curve independent on the growth of the control group of individuals belonging to the defined species under investigation. The calculation of the growth values occurs from the input data characterizing the organism, its nourishment, its basic biophysical parameters and the cooling power of the environment.

## METHODS

Selfregulating growth model, generates the growth curve from the differential of the body mass (dG), and its specific amount of the gross energy (SGEG). From the mathematical point of view, the equation of the body mass differentials (1), represents the application of the basic physical law of the mass and energy conservation, to the conversion of the foodstuff's mass and energy to the organism's body mass and energy. The body mass increase (dG) in general named the product, with the gross energy content (SGEG) denotes, not only the body mass change or the fetus growth in the pregnant mammals, but also the milk produced in mammals, or the egg's laying in birds. The products formation however could be performed only from that part of the mass and metabolizable feed energy ingested, which was not transformed to the thermostatic heat (THF), neither to the heat produced under the influence of the various stressors (THX). Among these stressors (X) we consider for instance the influence of heat or cold, the motor activity, changes in the gravitational field, psychic stress and many others. The increase of body mass (of the product) in kilograms per individual per day (kg/i/d), is than expressed by the equation:

$$dG = [(IMEF - (THF+THX))/SGEG] \cdot QGL \quad [\text{kg/i/d}] \quad (1)$$

The quotient QGL expresses the biological quality, the degree of the left potency for the body mass growth. This quotient QGL is generated automatically as the function of the actual body mass. The selfregulating model calculates the value of the body mass increase from the input parameters describing the modelled organism by: the initial body mass (G<sub>0</sub>), the body mass of the adult individuals and species under investigation (GL<sub>i</sub>), the body core temperature (T<sub>i</sub>), the thermal insulation of the body core against the environment (I<sub>si</sub>), further the input data about the daily feeding dose (DFD) and the value of specific amount of the metabolizable energy in the eaten food (SMEF). The resulting daily amount of metabolizable energy taken in the food (IMEF) is than given by the equation:

$$IMEF = DFD \cdot SMEF \quad [\text{MJ/kg/d}] \quad (2)$$

In the real time, expressed as the age of the modelled organism, the mass differential (dG) is calculated for the environmental temperature of the optimal product generation (T<sub>op</sub>), in a defined time interval (t). Calculated body mass changes e.g. increases, or in the case that the feeding is insufficient also decreases, are integrated to the actual body mass [G(t)]. The development of the body mass in the desired age points, G(t) values, are defined by the equation:

$$G(t) = G_0 + \int_0^t dG \cdot dt \quad [\text{kg/i}] \quad (3)$$

## RESULTS

For illustration, the results of modeling the body mass growth of female rats of the Wistar strain (BFU Brno) are presented in the Tab. I. Two groups of animals, each of ten individuals in the equal age, were bred in the same time in the room tempered to  $24 \pm 1^\circ \text{C}$ . The animals were housed in the standard umaplex cages, five individuals in each. The pelleted feed, with the specific amount of metabolizable energy  $\text{SMEF} = 12 \text{ MJ/kg}$ , was supplied regularly once a day. In the group A the feed was supplied in the limited DFD of 6 g, 12 g and 18 g as indicated in the Tab. I. The group C, during the whole experimental period, was supplied with the uniform DFD of 24 g. In drinking bottles water was to all animals accessible the whole day (Novák, Pipalová 1996).

From the experimental results presented in the tab. I. follows, that the DFD of 6 g was sufficient only for the maintenance of the body mass, and the body mass did not increase. In the age interval 42 - 52 days the DFD was increased twofold to the value of 12 g. The increase in the feed intake, was immediately followed by the steep increase of the body mass. However this body mass increase levelled up to the 60th day of age, despite the fact that the growth maturity, expressed by the QGL coefficient was not yet reached. The new body mass increase started again, after the DFD was increased to 18 g. The animals in the group C exhibited from the beginning a steep increase of the body mass. At the end of the experiment (on 85th day) they had at disposal the left potency for growth only 0,11. In comparison, the animals in the group A, have reached in average only 0,89 fraction of the average body mass of the group C, because of the limited feeding, at the end of the experiment however they had at disposal the twofold value of the left potency for growth e.g. 0,26 so that they were still able to increase the body mass further and would probably equalize the average of the body mass of the group C later under the appropriate DFD intake.

Tab. I. Experimental values of female rats growth and their comparison with the growth values calculated by means of the selfregulating growth model. Input data:  $\text{GLi} = 0,300 \text{ kg/l}$ ,  $T_i = 37,0^\circ \text{C}$ ,  $\text{Isi} = 0,155 \text{ m}^2 \cdot \text{K/W}$ ,  $\text{SMEF} = 12 \text{ MJ/kg}$ .

Group A, (N=10)								Group C, (N=10)							
Experimental values								Experimental values							
Age, days	25	32	42	50	60	75	85	25	32	42	50	60	75	85	
$\phi G \text{ g/l}$	90,0	94,3	92,2	151	171	195	229	91,3	126	169	201	220	251	257	
+SE l	1,07	0,97	1,42	1,34	1,39	2,39	2,82	1,26	1,28	2,32	2,81	2,58	2,94	2,39	
DFD g/l/d	6	6	12	12	12	18	18	24	24	24	24	24	24	24	
Calculations of SGM for the group A								Calculations of SGM for the group C							
$\phi G \text{ g/l}$	90,0	92,0	90,0	149	168	200	223	91	131	165	204	230	253	261	
MOBEG MJ/kg	3,5	3,5	3,5	3,5	3,5	6,0	7,0	5,0	5,0	9,0	9,0	9,0	15,0	15,0	
QGL	0,68	0,69	0,70	0,51	0,44	0,34	0,26	0,69	0,57	0,45	0,32	0,23	0,15	0,11	

## CONCLUSION

The comparison of the experimental values of body mass growth, with the values calculated by the selfregulating model of growth, clearly demonstrates that the calculated values sensibly follow the influence of the DFD on the body mass growth as it does the average value of body mass of the real experimental organisms. Moreover, from the figures of QGL it is evident how much of the potency for growth remains left, and also the values of SGFG indicate that the composition of the body mass increase depends on the value of DFD. From this point of view it is possible to consider the calculation of the selfregulating growth model as the reaction of a clearly defined "ideal control organism" which in general reacts on the DFD in a similar way as the real individuals in the described experimental conditions.

L. Novák. 1996: Selfregulating growth model in homoiotherms (SGM). *Acta Vet. Brno*, 65:107-114.

L. Novák, I. Pipalová. 1996: The modelling of the body mass development in the female Wistar strain rats, grown on regulated daily doses of the standardized feeding. *Scripta Medica (Brno)* 69:179-190.



## THE FRACTIONATION OF HYDROGEN AND OXYGEN STABLE ISOTOPES BY LIFE SUPPORT SYSTEMS OF SPACE STATION "MIR"

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### INTRODUCTION

The stable isotopes of chemical elements have distinctive chemical, biochemical and biophysical properties inspite of identical electron orbits. These distinctive properties are particularly evident in light elements. Compounds containing heavy isotopes have different biological influences than the similar compounds containing normal isotopic elements. For example, heavy water containing high concentrations (>80%) deuterium has toxic properties: plants, mice, rats, dogs, have died after being exposed to heavy water. The life support systems must generate and support optimal isotope composition in the habitable environment. The first stage of this research was the investigation of the hydrogen and oxygen stable isotope fractionation by water and atmosphere regeneration systems in ground-based mock-ups and systems which are on "MIR" station.

### METHODS

In this research we studied the fractionation of the hydrogen isotopes (protium and deuterium) and oxygen isotopes (O-16, O-18) by the regeneration systems ("SRW-C", "SRW-U" and "Electron") on space station "MIR". The isotopic composition of the regenerated water and atmospheric condensate was determined by the mass-spectrometric method.

### RESULTS

It was shown that each regeneration system changed the isotopic composition of the water and atmosphere. This effect will influence the isotope composition of habitable environment of the space station during long missions. It was established that fractionation of hydrogen and oxygen isotopes takes place during the first stages ("SRW-C") of the regeneration system. The water obtained from "SRW-U" was found to be enriched by light hydrogen and oxygen isotopes. The fractionation coefficients of hydrogen and oxygen isotopes in water, regenerated from urine by "SRW-U" are less than 1 and increase in accordance with degree of the water extraction from urine. The concentration remaining after urine evaporation is enriched with the heavy isotopes of hydrogen and oxygen. Removal of the concentrate from the regeneration system "SRW-U" leads to removing heavy isotopes from the ecological system. The generated oxygen from mock-up system of "Electron" is enriched by heavy isotope O-18. This finding may be explained by the long-duration utilization of electrolyte in this system. Analysis of stored water, atmospheric condensate, and regenerated water from the system, "SRW-C", were conducted for the presence of protium, deuterium, O-16 and O-18 in samples delivered from the long-duration orbital station "MIR" during MIR 20 and MIR 21 expeditions. It was found that these samples were slightly enriched with the light isotopes of oxygen and hydrogen with respect to the stored water. The potable water which is delivered to MIR by the STS "Shuttle" is enriched with the light isotope of hydrogen by 0.05 to 0.1% and the heavy isotope of oxygen by .02 to .03%.

### CONCLUSIONS

In order to predict the isotope composition of a habitable environment during the long-time space missions, it is necessary to investigate fractionation coefficients of the isotopes in all parts of ecological system including the man.

## EFFECT OF SPACE FLIGHT ON NEUTROPHIL FUNCTION

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### INTRODUCTION

Alterations in immune capabilities, as a function of space flight (microgravity), have been suggested by a number of recent studies. Recruitment and sequestration of polymorphonuclear (PMN) and monocytic leukocytes are fundamental responses to injury. The current data available indicates deficiencies in several aspects of humoral and lymphocyte-mediated response capabilities. In this study we sought to explore the effects of spaceflight on neutrophil chemotaxis, adhesion, and adhesion molecule expression.

### METHODS

Peripheral blood neutrophils were purified from crew members of Space Shuttle missions at 10 days before lift-off (L-10), 3 days (L-3), recovery day (R+0), and 3 days after recovery (R+3). The neutrophils were labeled with a fluorescent dye (2', 7'-bis-(2-carboxyethyl)-5( and -6)-carboxyfluorescein (BCECF/AM)), and quantitatively tested for their ability to directionally migrate in response to several doses of formyl-Methionyl-Leucyl-Phenylalanine (fMLP). The ability of BCECF/AM-labeled neutrophils to adhere to tumor necrosis factor-stimulated human umbilical vein endothelial cells (HUVECs) was also quantitatively tested. Adhesion molecule expression was analyzed by flow cytometry.

### RESULTS

At landing, in some cases there was approximately a 2-fold increase in the number of peripheral blood neutrophils as compared to mean preflight levels. Band neutrophils were observed at L-10 and R+0 on some missions. The chemotactic results show a 10-fold decrease in the optimal dose response to fMLP at R+0 or R+3. This suggested an alteration in the neutrophils ability to respond to fMLP and not in cell number. The expression of L-selectin was significantly increased at landing; CD11b (Mac-1), a member of the integrin family of adhesion molecules, was significantly decreased. Neutrophil adhesion to HUVECs was also significantly increased at R+0.

### CONCLUSION

The results of this study indicate that the chemotactic response of neutrophils is altered post-flight. The increase in chemotactic activity may reflect an increased or hypermetabolic state of the neutrophils, possibly due to the combined stress hormones released during reentry and landing. To further define the role of the effects of space flight on phagocytic cell function, future experiments are planned to address oxidative burst and phagocytosis of microorganisms.